DRAFT JUN 19 1996

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: UNMANNED AIR VEHICLE MAINTENANCE

Date: XX/XX/96 **AC No:** XX-XX
Initiated by: XXX-XXX **Change:**

1. PURPOSE. This advisory circular (AC) provides information and guidance to the aviation community on the maintenance of unmanned air vehicles (UAVs) used in the National Airspace System (NAS). The guidance provided within this AC pertains to the maintenance of UAVs and their air vehicle control stations (AVCS), and the qualifications, training, experience, and suggested currency criteria for personnel engaged in the maintenance, preventive maintenance, repair, alteration, or inspection of UAVs.

2. EFFECTIVE DATE. This AC becomes effective [*insert effective date*].

3. RELATED FEDERAL AVIATION REGULATIONS (FAR).

a. Title 14 Code of Federal Regulations (14 CFR) part 1, Definitions and abbreviations.

b. 14 CFR part 43, Maintenance, preventive maintenance, rebuilding, and alteration.

c. 14 CFR part 65, Certification: Airmen other than flight crew members.

d. 14 CFR part 91, General operating and flight rules.

e. 14 CFR part 145, Repair stations.

f. 14 CFR part 147, Aviation maintenance technician schools.

4. RELATED READING MATERIAL.

a. AC XX-XX, Unmanned Air Vehicle Design Criteria, dated [*insert date*].

b. AC XX-XX, Unmanned Air Vehicle Operator Qualification and Training, dated [*insert date*].

c. AC XX-XX, Unmanned Air Vehicle Operations, dated [*insert date*].

d. AC 43-9B, Maintenance Records, dated January 9, 1984.

e. AC 43.13-1A, Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair, dated April 17, 1972.

f. AC 43.13-2A, Acceptable Methods, Techniques, and Practices - Aircraft Alterations, dated June 9, 1977.

g. AC 65-12A, Airframe and Powerplant Mechanics Powerplant Handbook, dated April 12, 1976.

h. AC 65-15A, Airframe and Powerplant Mechanics Airframe Handbook, dated April 12, 1976.

5. BACKGROUND.

a. Because most UAV operations to date have been conducted by the Department of Defense (DoD) in Special Use Airspace (SUA), there is a lack of data regarding the civilian use of UAVs in the NAS.

b. New technology raises the prospect of significant growth in the civil UAV industry. Therefore, the Federal Aviation Administration (FAA) has determined a need for criteria and guidance for the maintenance of civil UAVs.

c. Maintenance practices vary greatly with the design and construction of each unmanned air vehicle. Standard aircraft maintenance practices should be followed to the maximum extent possible. Considerable valuable information can be obtained from the manufacturer of the vehicle and can be used as a basis to establish inspection and repair guidelines. The remotely piloted nature of UAVs makes it more difficult to evaluate in-flight problems; therefore, a sound maintenance program is vital to the safe operation of UAVs.

d. In its initial review of UAV operations, the FAA has determined that UAVs are sufficiently different from normal category airplanes certificated under the provisions of 14 CFR parts 21 and 23 to be considered a "special class" of aircraft under 14 CFR § 21.17. This determination is consistent with the definition of "class" found in 14 CFR § 1.1 and used with respect to the certification of aircraft.

e. The FAA has determined that it is premature to impose regulatory criteria on UAVs at this time. However, the FAA believes that the voluntary adoption of the guidance contained in this AC will maintain safety levels and increase public

confidence without imposing an undue cost during the period in which civil UAV operations in the NAS are conducted on a single-event basis.

6. DEFINITIONS. The following terms have the meaning listed when used in this AC.

a. Air Vehicle Control Station (AVCS). A flight deck on the ground without external flight environment cues used for the control of a UAV.

b. Autonomous Operation. A preprogrammed, automated flight profile that does not require human intervention for normal operation.

c. Built-In Test. A set of procedures performed internally by UAV systems to determine the degree of functionality of critical systems or components.

d. Catastrophic Failure. Any failure that leads to loss of the UAV and endangers people and/or property (i.e., a failure that prevents continued safe flight and landing).

e. Collision Avoidance Lighting. Lights or other visibility enhancements installed on a UAV that make the UAV easier to see and avoid in flight.

f. Crew Chief. The person responsible for completion of the pre-flight inspection and the post-flight inspection.

g. Critical Failure. Any failure that leads to UAV mission termination.

h. Critical System. A system or systems, the loss or malfunction of which would lead to a critical or catastrophic failure.

i. External Pilot. A UAV pilot who, in the absence of full automatic launch and recovery systems, visually controls the UAV flight path, generally during launch and recovery, from a site that provides direct visual contact with the UAV.

j. Flight Termination System. A controllable parachute or automatic preprogrammed course of action used to terminate flight in case of a catastrophic failure.

k. Internal Pilot. A UAV pilot who operates the UAV from a site that does not necessarily provide direct visual contact with the UAV. The internal pilot normally operates the UAV by means of commands sent to the UAV by radio link. Vehicle status and navigation information is received from the UAV via radio link.

An internal pilot also may consist of a hardware and/or a software system on board the UAV capable of providing flight path control inputs to the vehicle based on real-time environmental, system health/status, or tasking inputs; however, a ground-based internal pilot is responsible for monitoring autonomous operations.

l. Post-Flight Inspection. A set of functional tests of UAV systems and components, usually closely following the manufacturer's recommended tests or checklists, performed immediately upon the conclusion of each UAV mission.

m. Pre-Flight Inspection. A set of functional tests of UAV systems and components, usually closely following the manufacturer's recommended tests or checklists, performed before each launch of a UAV.

n. Propulsion System. A system comprised of those components necessary to ensure the safe propulsion of the UAV.

o. Skill Levels. General eligibility requirements recommended by the UAV manufacturer, formal classroom education, and approved apprenticeships needed to be completed in order to perform inspections, maintenance, and repair of a UAV.

p. Unmanned Air Vehicle (UAV). An air vehicle that does not carry a human operator, and is capable of flight beyond visual line of sight under remote or autonomous control for civil (non-DoD) purposes. A UAV is considered nonexpendable if engaged in operations other than hazardous or oceanic meteorological observation operations.

7. GENERAL. For purposes of determining UAV airworthiness, the air vehicle and all support equipment, including any ground control, telemetry, or monitoring equipment, should be considered components of the UAV system. The recommendations of this AC apply equally to each component of the UAV system.

8. PERSONNEL.

a. Training and Skill Level. Inspection, maintenance, and repair personnel should have an established skill level sufficient to safely perform the functions of their position. This could include a mix of formal and informal training, including on-the-job training. Personnel performing maintenance should have experience in working on aircraft and aircraft systems.

b. Currency. The UAV operator should establish training, experience, and currency requirements for its maintenance and

inspection personnel. The currency requirements should be established such that the training curriculum has been completed prior to performing tasks and/or the person has had apprenticeship/work experience in the task area within the previous 24 months.

c. Crew Chief. A crew chief should be assigned responsibility for the system's functionality and performance for each UAV mission.

9. MANUFACTURER GUIDANCE.

a. For each model of UAV produced, the manufacturer should develop, prepare, and provide to the operator, and the operator should maintain, manuals containing the following recommended procedures:

(1) Inspection Procedures. Pre- and post-flight inspection procedures, including the frequency of inspections, a listing of necessary equipment, and the skill levels necessary to perform the inspections.

(2) Maintenance Procedures. Diagnostic procedures and procedures for the repair and replacement of components, including a listing of necessary equipment and the skill levels required to perform the procedures.

(3) Repair Station Procedures. Recommendations on the minimum and preferred tools for field and base facilities.

(4) In-Flight Diagnostics Procedures. Mission abort thresholds and recommended actions for in-flight systems' shutdown and return to base.

b. It would be expected that, at least for some initial period, the manufacturer of each UAV should provide vehicle-specific maintenance and inspection training.

10. GENERAL MAINTENANCE GUIDELINES.

a. Maintenance and repair of UAVs should follow the guidance given in AC No. 43.13-1A and AC No. 43.13-2A, unless indicated otherwise in this AC.

b. Maintenance of UAVs and ground control equipment should be governed by the manufacturer's recommended periods of inspection and overhaul as applicable.

11. RECORDKEEPING.

a. For each UAV, a log book should be maintained. In this logbook, the UAV operator should maintain records of all maintenance actions performed on that specific UAV. Notes should be made of every action showing compliance with any applicable maintenance directives.

b. For each UAV, a discrepancy log should be maintained, indicating any discrepancies found during any preflight or post-flight inspection, and the status of corrective action taken.

c. Each part used in UAV repair and maintenance should be documented to meet the manufacturer's or operator's specifications, whichever are more stringent. It should be the crew chief's responsibility to certify that each part or material incorporated into a UAV structure or used in UAV repair meets or exceeds these specifications. The crew chief should maintain a log of all parts used in UAV maintenance and repair. This log should be sufficiently detailed to allow tracing of each item used in maintenance or repair of the UAV to the manufacturer of that item, as well as a lot or batch identification of that item.

12. BUILT-IN TEST.

a. Each aircraft should provide for access, either in the form of an aircraft mounted display or a plug-in type display, to an internal set of software procedures designed to exercise critical components and systems, and provide a state of system health. This information should be available to the pilot operating the UAV during flight.

b. Also included should be a set of diagnostic procedures to aid fault location. For in-flight use, these procedures should include the amount of emergency power reserve remaining.

13. COLLISION AVOIDANCE SYSTEM (CAS). The CAS on board each UAV, if installed, should be exercised prior to each flight in accordance with manufacturers' recommended procedures.

14. FLIGHT TERMINATION SYSTEM (FTS).

a. The FTS, if installed, should be inspected in accordance with manufacturers' instructions prior to and immediately following each flight.

b. A qualified Crew Chief should be responsible for preparing, engaging, and disarming an FTS for each flight.

c. The FTS should undergo an inspection at an FAA-certificated repair station or manufacturer's recommended facility on a schedule recommended by the manufacturer.

15. PRE-FLIGHT INSPECTION.

a. The pre-flight inspection should be a thorough examination of the UAV's safety-critical systems and mission-critical systems to determine that the UAV is capable of completing its mission safely. It should be the crew chief's responsibility to certify that the UAV is safe to fly the planned mission. Failure of any safety-critical or mission-critical UAV system to perform to this level of capability should result in cancellation of the flight.

b. Any additional manufacturer-recommended pre-flight actions for other systems should also be performed in accordance with those specified.

c. Any discrepancies that result in cancellation of a flight, or that, if not corrected, could have an impact on the safety of a mission, should be entered in the discrepancy log.

16. POST-FLIGHT INSPECTION.

a. The post-flight inspection should be a thorough examination of all UAV systems to determine that the UAV has not experienced any unusual wear or damage in the mission just completed, and that the performance of all UAV systems remains within the manufacturer's or operator's specifications, whichever are more stringent. It should be the crew chief's responsibility to conduct the post-flight inspection. Failure of any system to perform to this required level of capability should result in the removal of the UAV from service until appropriate maintenance and repair actions are completed and subsequent inspection by the crew chief determines that all UAV systems are performing within the manufacturer's or operator's specifications, whichever are more stringent.

b. Any additional manufacturer-recommended post-flight actions for other systems should also be performed in accordance with those specified.

c. Any discrepancies that ground the UAV until corrected, or that could have an impact on the safety of a mission, should be entered in the discrepancy log.

17. ADDITIONAL GUIDANCE. Operators of UAV designs, and operators of UAVs engaged in applications that, because of mission requirements or hazardous conditions, cannot comply with the suggested training criteria specified in this AC, should contact the nearest FAA Regional Office for further information and guidance.

18. COMMENTS INVITED. Comments regarding this publication should be directed to:

Department of Transportation
Federal Aviation Administration
Attn:

Washington, DC 20591

Thomas C. Accardi
Director, Flight Standards Service

U.S. Department of Transportation
Federal Aviation Administration

DRAFT Advisory Circular

Subject: UNMANNED AIR VEHICLE PILOT QUALIFICATION AND TRAINING **Date:** XX/XX/96 **Initiated by:** XXX-XXX **AC No:** XX-XX **Change:**

1. PURPOSE. This advisory circular (AC) provides information and guidance to the aviation community on the qualification and training of pilots of unmanned air vehicles (UAVs).

2. EFFECTIVE DATE. This AC becomes effective [*insert effective date*].

3. RELATED FEDERAL AVIATION REGULATIONS (FAR).

a. Title 14 Code of Federal Regulations (14 CFR) part 1, Definitions and abbreviations.

b. 14 CFR part 61, Certification: Pilots and flight instructors.

c. 14 CFR part 91, General operating and flight rules.

d. 14 CFR part 141, Pilot schools.

e. 14 CFR part 143, Ground instructors.

4. RELATED READING MATERIAL.

a. AC XX-XX, Unmanned Air Vehicle Design Criteria, dated [*insert date*].

b. AC XX-XX, Unmanned Air Vehicle Maintenance, dated [*insert date*].

c. AC XX-XX, Unmanned Air Vehicle Operations, dated [*insert date*].

d. Aeronautical Information Manual (AIM), U.S. Department of Transportation, Federal Aviation Administration.

5. BACKGROUND.

a. Although extensive experience has been gained with UAVs operated by the Department of Defense (DoD), there is a lack of data pertaining to the civilian use of UAVs.

b. The prospect of significant market growth in civil UAV operations has prompted the Federal Aviation Administration (FAA) and the aerospace industry to establish recommendations for UAV pilot qualification and training. Although these recommendations are not regulatory, the FAA believes that voluntary adoption of these recommendations by the segments of the aerospace industry involved in UAV operation will ensure that appropriate safety levels are maintained and that public trust in UAV operations is strengthened. Additionally, this gradual approach toward implementation of UAV pilot certification and training criteria should promote the technological development of civil UAV operations without putting an unreasonable economic burden on the industry.

c. The task of establishing a set of acceptable UAV qualification and training criteria is complicated by the wide variety of UAV sizes and types envisioned for production, the diversity of possible UAV operations, and consequently, uncertainty as to what pilot knowledge and skills may be generally needed.

d. Although there may be significant operational differences between UAVs and other air vehicles, in order for UAVs to share the same airspace and ATC services, the FAA recommends that UAV pilots also should hold certain minimum qualifications of existing FAA pilot certificates.

e. The data collected and experience gained in future civil UAV operations will provide the FAA and the aerospace industry with the expertise necessary to determine the best methods of controlling and integrating this new activity into the National Airspace System (NAS).

6. DEFINITIONS. The following terms have the meaning listed when used in this AC.

a. Air Vehicle Control Station. A flight deck on the ground without external flight environment cues used for the control of a UAV.

b. Autonomous Operation. A preprogrammed, automated flight profile that does not require human intervention for normal operation.

c. Close Supervision of an Experienced UAV Pilot. A situation in which a UAV student operates the UAV, but a UAV pilot who meets the qualification criteria of this AC and can monitor all of the UAV instruments can immediately take control of the UAV at any time deemed necessary by the pilot in command. The supervising pilot should have operated or acted as pilot in command of the particular make and model of UAV for a minimum of 15 hours under IFR if the supervision is of internal pilot operations, or a minimum of 25 takeoffs and landings if the supervision is of external pilot operations.

d. External Pilot. A UAV pilot who, in the absence of full automatic launch and/or recovery systems, visually controls the UAV flight path, generally during takeoff and landing, from a site that provides direct visual contact with the UAV.

e. Internal Pilot. A UAV pilot who operates the UAV from a site that does not necessarily provide direct visual contact with the UAV. The internal pilot normally operates the UAV by means of commands sent to the UAV by radio link. Vehicle status and navigation information is received from the UAV also via radio link. An internal pilot also may consist of a hardware and/or a software system on board the UAV capable of providing flight path control inputs to the vehicle based on real-time environmental, system health/status, or tasking inputs; however, a ground-based internal pilot is responsible for monitoring autonomous operations.

f. Pilot In Command. For UAVs, the pilot in command is defined as the designated pilot within the controlling air vehicle control station tasked with overall responsibility for operation and safety of the UAV in flight. This may be the pilot physically sitting at the control console or the designated mission commander. In cases where UAV control is passed from one control station to another, change in pilot in command occurs upon acknowledgment of successful completion of control authority transfer by the new controlling station. The external pilot, if used, should be the pilot in command while the UAV is under his or her control for launch or recovery.

g. Propulsion System. A system comprised of those components necessary to ensure the safe propulsion of the UAV.

h. Unmanned Air Vehicle (UAV). An air vehicle that does not carry a human operator, and is capable of flight beyond a visual line of sight under remote or autonomous control for civil (non-DoD) purposes. A UAV is considered nonexpendable if engaged in operations other than hazardous or oceanic meteorological observation operations.

7. GENERAL. The recommendations contained in this AC apply to all UAV operations conducted within the NAS, other than those conducted solely within restricted areas or warning areas.

8. UAV PILOT QUALIFICATIONS.

a. Medical Qualifications. At a minimum, a third-class medical certificate should be held by a UAV pilot. Because the air vehicle control station is not subjected to rapid changes in atmospheric pressure, physical ailments due to barometric sensitivity as anticipated in FAR § 67.17(c) may be waived with the appropriate marking on the medical certificate "UAV operation only."

b. Certification. Prior to operating a UAV without the close supervision of an experienced UAV pilot, the pilot of a UAV should possess at least a private pilot certificate, with an appropriate category rating as follows:

(1) An airplane rating, for the operation of a fixed-wing UAV.

(2) A rotorcraft rating, for the operation of a rotary-wing UAV.

c. Initial Training.

(1) Equivalent Level of Training. Prior to operating a UAV without the close supervision of an experienced UAV pilot, the pilot of a UAV should, at a minimum, have the training and experience in the safe operation of the specific UAV being operated equivalent to that required for the pilot of an aircraft having similar performance characteristics under similar air traffic and weather conditions.

(2) Ground Instruction. A person wishing to operate a UAV should, prior to operating a UAV without the close supervision of an experienced UAV pilot, receive ground instruction that takes into account the inherent differences between UAVs and manned aircraft, as indicated by the UAV manufacturer. Instruction should cover these differences between UAVs and manned aircraft in at least the following subjects:

(i) Aerodynamics and principles of flight;

(ii) Structures, flight controls, electrical systems, navigation systems, propulsion systems, communications systems, and data link description and principles;

(iii) Flight instruments, displays, and interpretation.

(iv) UAV performance.

(v) Weather limitations.

(vi) Navigation skills, including dead reckoning, pilotage, and the use of electronic aids to navigation.

(vii) The use of flight information publications.

(3) Aeronautical Knowledge. Prior to operating a UAV without close supervision by an experienced UAV pilot, a person wishing to operate a UAV should complete a test administered by an authorized instructor covering, as a minimum, all of those knowledge areas listed in paragraph (2) above.

(4) Instructional Flight Experience and Proficiency. Persons should be trained on the specific equipment they will operate. A computerized control system is envisioned as the best approach for control of UAVs, and this concept is completely compatible with computer-aided training. Prior to operating a UAV without the close supervision of an experienced UAV pilot, a person wishing to operate a UAV should receive any supplemental training that is recommended by the UAV manufacturer and agreed upon by an FAA Inspector trained in UAV operations. Training supplemental to that received under part 61 may be expected particularly with respect to FAR §§ 61.99, 61.107, and 61.109 (in the case of a fixed-wing UAV); and §§ 61.100 and 61.113 (for a rotary wing UAV), because range and duration of flight may be significantly different from manned aircraft. The prospective UAV pilot should have logged instruction from an authorized instructor, and the applicant's logbook should contain an endorsement by an authorized instructor who has found the applicant competent to perform each of those operations listed in FAR § 61.107, as appropriate for that make and model of UAV. Appropriate operations should include those operations the prospective pilot can be reasonably expected to perform for that make and model, including normal, abnormal, and emergency procedures.

(5) Check Flight. Prior to operating a UAV without the close supervision of an experienced UAV pilot, a person wishing to operate a UAV should complete a check flight, including both an oral component and a practical component. This check flight should be administered by a competent and experienced UAV pilot, and should be in the format of an FAA-approved private pilot practical test. The person administering this check flight should seek to determine whether the person taking the check flight is sufficiently skilled and knowledgeable to operate a UAV in a safe manner and without posing a safety risk to other aircraft, persons, or property.

d. Recency of Experience. Each UAV operator should establish its own recency of experience requirements for its UAV pilots. At a minimum, the following criteria are recommended in order for a person to operate a UAV without the close supervision of an experienced UAV pilot:

(1) External pilots should have performed three actual takeoffs and landings to a full stop in the make and model of UAV within the previous 90 days.

(2) Internal pilots should have performed 6 hours as the crewmember of a UAV operating IFR within the previous 180 days. At least 2 of the 6 hours should be performed while operating a UAV in actual flight.

9. UAV PILOT-IN-COMMAND CERTIFICATION AND TRAINING.

a. Certification. Other than when operating in the capacity of an external pilot, the pilot in command of a UAV should possess at least a commercial pilot certificate with an instrument rating in the appropriate aircraft category rating as follows:

(1) An airplane rating, for the command of a fixed-wing UAV.

(2) A rotorcraft rating, for the command of a rotary-wing UAV.

b. Initial Training. A UAV pilot in command should meet all of the initial training criteria listed for UAV pilots. [*Additional criteria, if any, to be determined following further guidance.*]

c. Recency of Experience. In order to act as pilot in command of a UAV, other than in the capacity of external pilot, a person should meet all of the recency of experience criteria listed in paragraph 8.d.(2) above for UAV internal pilots. [*Additional criteria, if any, to be determined following further guidance.*]

10. UAV GROUND AND FLIGHT INSTRUCTORS.

a. General. Whenever practicable, UAV ground and flight instruction should be provided by FAA-certificated ground and flight instructors who have significant UAV operating experience.

b. UAV Ground Instructor. Ground instruction should be provided by a certificated ground instructor under FAR part 143 who is endorsed by the UAV manufacturer(s) as being competent to

teach those aspects peculiar to the UAV system. For some very basic UAV systems, it may be appropriate that no more than a certificated ground instructor be required to train the UAV pilot in preparation for the check flight.

c. UAV Flight Instructor. Flight instruction should be provided by a certificated flight instructor under FAR part 61 who is endorsed by the UAV manufacturer as being competent to teach those aspects peculiar to the UAV system.

11. ADDITIONAL GUIDANCE. Operators of UAV designs and operators of UAVs engaged in applications that, because of mission requirements or hazardous conditions, cannot comply with the suggested training criteria specified in this AC, should contact the nearest FAA Regional Office for further information and guidance.

12. COMMENTS INVITED. Comments regarding this publication should be directed to:

Department of Transportation
Federal Aviation Administration
Attn:
Washington, DC 20591

Thomas C. Accardi
Director, Flight Standards Service

US Department of Transportation
Federal Aviation Administration

Advisory Circular

JUL 15 1994

DRAFT

Subject:	UNMANNED AIR VEHICLE DESIGN CRITERIA	Date: / Initiated by:	ATP-200	AC No: / Change:	xx-xx

1. PURPOSE. This advisory circular (AC) provides information and guidance to the aviation community on design specifications for unmanned air vehicles (UAV(s)). The guidance provided within this AC pertains to the design of typical UAV elements such as flight control, electrical, communications/data link, navigational, propulsion, air vehicle control station, flight termination, and structures.

2. EFFECTIVE DATE. This AC becomes effective

3. RELATED FAR SECTIONS.

a. 14 Code of Federal Regulations (CFR) part 1, Definitions and abbreviations.

b. 14 CFR part 21, Certification procedures for products and parts.

c. 14 CFR part 23, Airworthiness standards: normal, utility, acrobatic, and commuter category airplanes.

d. 14 CFR part 27, Airworthiness standards: normal category rotorcraft.

e. 14 CFR part 33, Airworthiness standards: aircraft engines.

f. 14 CFR part 35, Airworthiness standards: propellers.

g. 14 CFR part 36, Noise standards: aircraft type and airworthiness certification.

h. 14 CFR part 39, Airworthiness directives.

i. 14 CFR part 43, Maintenance, preventive maintenance, rebuilding, and alteration.

FAA Form 1320-15 (4-82) Supersedes WA Form 1320-2

j. 14 CFR part 45, Identification and registration marking.

k. 14 CFR part 91, General operating and flight rules.

4. RELATED READING MATERIAL.

a. Joint Aviation Authorities (JAA) Joint Aviation Requirements for Very Light Aeroplanes (JAR-VLA).

b. JAA Joint Airworthiness Requirements for Sailplanes and Powered Sailplanes (JAR 22).

c. AC 21.17-3, Type Certification of Very Light Airplanes under FAR § 21.17(b), dated December 21, 1992.

d. AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes, dated February 9, 1989.

e. AC 23-11, Type Certification of Very Light Airplanes with Powerplants and Propellers Certified to Parts 33 and 35 of the Federal Aviation Regulations, dated December 2, 1992.

5. BACKGROUND.

a. Extensive experience has been gained with UAV(s) operated by the Department of Defense (DOD) in Special Use Airspace. However, because civilian use of UAV(s) in the National Airspace System (NAS) is limited, there is a lack of civilian experience in UAV operations and a lack of data relating to UAV use in non-DOD operations.

b. In its initial review of UAV design criteria and operations, the Federal Aviation Administration (FAA) has determined that UAV(s) are sufficiently different from normal category airplanes certificated under the provisions of part 21 and part 23 to be considered a "special class" of aircraft under § 21.17 of the Federal Aviation Regulations (FAR). This determination is consistent with the definition of "class" as found in § 1.1 of the FAR and used with respect to the certification of aircraft.

c. The prospect of significant market growth in civil UAV operations has prompted the FAA and the aerospace industry to establish suggested criteria for UAV design and operation. Those criteria are provided as suggested design guidelines only and they are not intended to dictate given design solutions to UAV manufacturers. Alternative design solutions meeting the intent of these criteria or more suitably adapted to the envisaged type of UAV application and category may also be found acceptable. Although these criteria are not regulatory, the FAA asserts that the voluntary adoption of these criteria by the segments of the aerospace industry involved in UAV design and operation should

ensure that appropriate safety levels are maintained and public trust in UAV operations is gained. Additionally, this gradual approach toward the implementation of design and operational criteria should promote the technological development of civil UAV design and operations without putting an unreasonable economic burden on the industry.

d. Some of the difficulties currently encountered in establishing a set of acceptable UAV design and operational criteria result from the wide variety of UAV sizes and UAV types envisioned for production and from the diversity of UAV operations. Some UAV design criteria may apply to all UAVs and some may be unique to certain types and classes of vehicles. Future UAV design and operational provisions should eventually accommodate virtually all classes of UAVs and all types of UAV use. The data collected and experience gained in future civil UAV operations should also provide the FAA and the aerospace industry with the expertise necessary to adequately determine the best methods of controlling and integrating this new activity into the NAS.

6. DEFINITIONS. The following terms have the meaning listed when used in this AC.

a. Air Vehicle Control Station. The flight control station used to operate the UAV(s) via remote control.

b. Autonomous Operation. A programmable, automated flight profile that does not require human intervention for normal operation.

c. Catastrophic Failure. Any failure that leads to loss of the UAV(s) and endangers people and/or property.

d. Critical Failure. Any failure that leads to UAV flight interruption or termination.

e. Critical System. A system or systems, the loss or malfunction of which, would lead to a critical failure.

f. External Pilot. A UAV operator who, in the absence of full automatic takeoff and landing systems, visually controls the UAV flight path, generally during takeoff and landing.

g. Flight Termination System. A controllable parachute or automatic preprogrammed course of action used to terminate flight in case of a critical failure.

h. Internal Pilot. A person who operates the UAV(s) from a site that provides direct contact with the UAV(s). This pilot normally operates the UAV(s) by means of commands sent to the UAV(s) by radio link. Vehicle status and navigation information

is received from the UAV(s) via radio link. This pilot also may operate the UAV(s) by a hardware and/or software system on board the UAV(s) capable of providing flight path control inputs to the vehicle based on real-time environmental, system health/status, or tasking inputs. This pilot is responsible for monitoring autonomous operations.

i. Propulsion System. A system comprised of those components necessary to ensure the safe propulsion of the UAV(s).

j. Unmanned Air Vehicle (UAV). A UAV is an aircraft capable of flight beyond visual line of sight under remote or autonomous control for civil (non-Department of Defense) purposes. A UAV is not operated for sport or hobby and does not transport passengers or crew.

7. DISCUSSION.

a. Safety Standard. UAV operations should be as safe as manned aircraft insofar as they should not present or create a hazard to persons or property in the air or on the ground greater than that created by manned aircraft of equivalent class or category.

b. Registration. The FAA envisions that some form of vehicle registry and identification eventually may be required to track the information required for UAV reliability and failure rates. Vehicle registry information would be coordinated through the FAA's Civil Aviation Registry Division (AVN-400).

c. Technical Issues and Related Criteria.

(1) Advisory Circular 21.17-3, which pertains to the type certification of very light airplanes, serves as a general basis for UAV structural design criteria.

(2) Fail-safe principles should govern the design of UAV systems. System independence and/or adequate redundancy and back-up features should provide for safe functioning of the UAV(s) in the event of a system failure.

(3) Any system design should provide for a failure detection apparatus (pre-flight and in-flight built-in-test) that will notify the UAV operator of a system failure. Adequate procedures for the safe operation of the UAV(s) following a system failure and procedures for the automatic recovery of the UAV(s) should be clearly defined. Potential human UAV operator errors should be considered by UAV designers and adequate provisions should be taken to minimize the effects of such errors. Additionally, an engineering analysis of any UAV design should be submitted to the responsible Aircraft Certification Service office to assist the FAA in the further review of UAV

design criteria. The following are considered critical system design criteria for UAV(s):

(i) RTCA DO 178B. All UAV system software verification and validation activities should be performed in accordance with RTCA DO 178B.

(ii) Flight Control System. The flight control system may include UAV operator controls, sensors, computers, and actuation parts necessary to control the UAV flight trajectory. The system should ensure adequate stability throughout the UAV's expected flight envelope. Any single failure of the flight control system should not significantly affect the operator's ability to control UAV recovery. Provisions for possible reversion to degraded modes of operation also should be incorporated into flight control system design. The UAV(s) should remain controllable in the event of a propulsion system failure.

(iii) Electrical System. The electrical system should provide sufficient power and endurance to ensure safe operations and recovery throughout all phases of flight. In the event of an emergency, the electrical system or emergency power supply should be of sufficient size to enable recovery at either the intended or a predetermined/alternate recovery area.

(iv) Communications System/Data Link. Approval for all frequencies used in UAV operations must be obtained from the Federal Communications Commission (FCC). The maximum range of the communication link should be determined and substantiated by the UAV operator. Any single failure of the communications system (uplink or downlink) should not affect normal control of the UAV(s). Uplinks/downlinks are sensitive to electromagnetic interference (EMI) and should be adequately protected from this hazard. Vehicle designs should incorporate provisions for a preplanned recovery of the UAV(s) in the event of a temporary or total loss of the communications system.

(v) Navigation System. The vehicle navigation system should meet the required navigation performance (RNP) standards for the airspace classification in which the operations are to be conducted. Navigation system designs should also consider the complexity and level of air traffic operations found in the airspace in which the UAV(s) will operate.

(vi) Propulsion System. All essential elements of the propulsion system, including the engine, engine controls, propeller, propeller components, and essential sensors, should meet documented reliability standards established by industry or U.S. specifications.

(vii) Air Vehicle Control Station.

(A) Manned aircraft cockpit features (e.g., control placement and ease of control column forces), do not have to be duplicated exactly. Station design should facilitate control of the UAV(s) by the internal pilot and provide for unambiguous operations and clear indications of UAV flight status. Design criteria should minimize the potential for human error. All "conventional" flight indications and warnings necessary to ensure safe control of the UAV flight path should be provided. In particular, the UAV internal pilot should be informed of any degraded mode of operations due to any failure, including cases in which there is an automatic switching to an alternate or degraded mode of operation. The control station should include a diagnostic and monitoring capability for the status of the vehicle. Real time, direct communications/surveillance, and data transmission capability should be provided in the absence of failure. For operations in controlled airspace, direct communications with the FAA controlling agency should be incorporated into the air vehicle control station system design.

(B) The minimum required number of UAV operators and provisions for related task sharing should be determined by mission requirements. If an external pilot used during the takeoff and landing phases of the flight receives flight parameter information via an intercommunication system from the air vehicle control station, the inner communications system between the operator and the control station should be as reliable as conventional flight instrumentation.

(viii) Flight Termination System. The UAV(s) should have a means of safely terminating flight of the vehicle in all phases of flight operations. The flight termination system should avoid the use of explosives to the maximum extent possible.

(ix) Aircraft Structure. The aircraft structure should be designed to withstand the maximum expected operational loads as determined by the intended operational flight envelope of the UAV(s). Aircraft structural design should meet the standards imposed by JAR-VLA or by part 23 or 27 of the FAR. Verification of structural static and dynamic strength and durability should be demonstrated by test and/or analysis.

d. Operational Safety Aspects.

(1) Operational approval, including mission profile aspects, should take into account the results of demonstrated compliance with the above design criteria. The following elements should be included in the vehicle to ensure safe operation of a UAV:

(i) A demonstrated means to comply with the equivalent level of safety afforded by the "see and avoid concept" applied to manned flight operations.

(ii) The minimum equipment required to operate in the desired class of airspace.

e. Data Collection.

(1) Detailed flight records should be maintained and provided to the responsible Aircraft Certification Service office upon request. This data will enable the FAA to determine the number, types, applications, and reliability of UAV(s). UAV operators should maintain a record of each flight. These records should be maintained by registration number (if applicable) and should include but should not be limited to the following information:

(i) Mission purpose

(ii) Payload type

(iii) Flight duration and altitude

(iv) Specific information on critical system failures.

8. ADDITIONAL GUIDANCE. Operators of UAV designs and operators of UAV(s) engaged in applications that, because of mission requirements or hazardous conditions, e.g., UAV(s) may be expendable, cannot meet the suggested design criteria and operational guidance specified in this AC should contact the nearest FAA Regional Office for further information and guidance.

9. COMMENTS INVITED. Comments regarding this publication should be directed to:

U.S. Department of Transportation
Federal Aviation Administration

DRAFT

Advisory Circular

JUN 19 1996

Subject: Unmanned Air Vehicle Operations **Date:** 6/18/96 **AC No:** XX-XX
Initiated by: AFS-XX **Change:**

1. PURPOSE. This advisory circular (AC) provides information and guidance to the aviation community on the operations of unmanned air vehicles (UAVs) in the national airspace system (NAS).

2. RELATED FEDERAL AVIATION REGULATIONS (FAR).

a. Title 14 Code of Federal Regulations (14 CFR) part 1, Definitions and abbreviations.

b. 14 CFR part 45, Identification and registration markings.

c. 14 CFR part 91, General operating and flight rules.

3. FORMS AND REPORTS. Letter of agreement for UAV operations in the NAS.

4. RELATED READING MATERIAL.

a. AC XX-XX, Unmanned Air Vehicle Design Criteria.

b. AC XX-XX, Unmanned Air Vehicle Maintenance.

c. AC XX-XX, Unmanned Air Vehicle Operator Qualification and Training.

d. AC 61-27C, Instrument Flying Handbook, dated November 11, 1980.

e. Aeronautical Information Manual (AIM), U.S. Department of Transportation, Federal Aviation Administration.

5. BACKGROUND.

a. Although extensive experience has been gained with UAVs operated by the Department of Defense (DOD), most of this activity has taken place within restricted areas and warning areas, i.e., special use airspace (SUA). There has been no established criteria for authorizing civil UAV flights in the

NAS. Because civilian use of UAVs in the NAS has been limited, there is a lack of data relating to UAV use in non-DOD operations.

b. Today's technology may significantly expand the commercial use of UAVs. This development creates the need for criteria and other guidance for the UAV industry.

c. Because there is not enough historical or current data relating to civil UAV operation, the FAA does not believe that it is advisable to establish extensive regulatory criteria at this time. The FAA concludes that a systematic strategy towards the formulation of regulatory criteria based on experience gained from civil UAV applications in the NAS is more practical. Each evolution in this developmental process will be determined by the success demonstrated by the preceding activity. The progress of any regulatory actions should be founded on the documented ability of civil UAVs to operate safely in the NAS and also perform in conformity with the existing air traffic control (ATC) system without adversely affecting manned aircraft flights.

d. The safety standard that should be maintained is one in which UAVs engaged in nonexpendable operations are operated as safely as manned aircraft, insofar as they should not present or create a hazard to persons or property in the air or on the ground greater than that created by manned aircraft conducting similar operations. The FAA asserts, therefore, that the overall probability of a UAV creating a hazard in a nonexpendable operation should not exceed 1×10^{-9}.

e. There are two significant sources of risk that UAV operations may create that manned aircraft operations do not: (1) the absence of a visual see-and-avoid capability equivalent to that of human pilots visually scanning for other air traffic; and (2) the absence of real-time control capability in the event that the UAV loses its control links with the ground.

f. Although these recommendations are not regulatory, the FAA believes that voluntary adoption of these recommendations by the segments of the aerospace industry involved in UAV operations will ensure that appropriate safety levels are maintained and that public trust in UAV operations is strengthened. Additionally, this gradual approach toward implementation of operations criteria should promote the technological development of civil UAV operations without putting an unreasonable economic burden on the industry.

6. DEFINITIONS. The following terms and definitions apply to this AC.

a. Air Vehicle Control Station (AVCS). A flight deck on the ground without external flight environment cues used for the control of a UAV.

b. Autonomous Operation. A preprogrammed, automated flight profile that does not require human intervention for normal operation.

c. Catastrophic Failure. Any failure that leads to the loss of the UAV and endangers people and/or property (i.e., a failure that prevents continued safe flight and landing).

d. External Pilot. A UAV operator who, in the absence of fully automatic takeoff and/or landing systems, visually controls the UAV flight path during launch and/or recovery, from a site that provides direct visual contact with the UAV.

e. Fix/Radial/Distance (FRD). A location described in the form of specific distance and magnetic bearing from a navigational fix, typically a navigational aid. For the purposes of this AC, it should be assumed that when an FRD is required to be entered on a flight plan or other form, the identifying code of the navigational fix should be followed by three digits for the magnetic bearing from the fix, followed by two digits for distance in nautical miles from the fix (e.g., BRV060031). However, when a location directly over a navigational fix is described, the radial and distance should be omitted.

f. Flight Crewmember. Any person who operates or acts as pilot in command of a UAV while it is operating for the purpose of flight, including any internal pilot, external pilot, or pilot in command used or required for that UAV operation.

g. Flight Termination System (FTS). A controllable parachute and/or other automatic preprogrammed course of action used to terminate flight in case of a catastrophic failure.

h. Internal Pilot. A UAV pilot who operates the UAV from a site that does not necessarily provide direct visual contact with the UAV. The internal pilot normally operates the UAV by means of commands sent to the UAV by radio link. Vehicle status and navigation information is received from the UAV also via radio link. An internal pilot may also consist of a hardware and/or a software system on board the UAV capable of providing flight path control inputs to the vehicle based on real-time environmental, system health/status, or tasking inputs; however, a ground-based internal pilot is responsible for monitoring autonomous operations.

i. Launch. The initial phase of flight of a UAV operation, commencing with the takeoff or liftoff. For a launch in which the UAV is operated by an external pilot, this phase can be considered terminated when the internal pilot takes control of the UAV. For a fully automated launch in which an external pilot is not used, this phase can be considered terminated at the point

where the UAV climbs through 2,000 feet above ground level (AGL), or maximum mission altitude, whichever is lower.

j. Pilot In Command. For UAVs the pilot in command is defined as the designated operator within the controlling air vehicle control station tasked with overall responsibility for operation and safety of the UAV in flight. This may be the operator physically sitting at the control console or the designated mission commander. When UAV control is passed from one control station to another, change in pilot in command occurs upon acknowledgment of the successful completion of control authority transfer by the new controlling station. The external pilot, if used, should be the pilot in command while the UAV is under his or her control for launch or recovery.

k. Recovery. The final phase of a normal UAV operation, terminating with the landing or touchdown. For a recovery in which the UAV is operated by an external pilot, this phase commences with the handoff of control from the internal pilot to the external pilot. For a fully automated recovery in which an external pilot is not used, this phase commences at the point at which the UAV descends through 2,000 feet AGL, or begins to descend from the maximum mission altitude, whichever is lower.

l. Unmanned Air Vehicle (UAV). An air vehicle that does not carry a human operator, and is capable of flight beyond the visual line of sight under remote or autonomous control for civil (non-DOD) purposes. A UAV is considered nonexpendable if engaged in operations other than hazardous or oceanic meteorological observation operations.

7. DISCUSSION.

a. Although the operation of a civil UAV is unique in many instances, many aspects of its operation are consistent with those of manned aircraft. Therefore, except where such provisions would clearly not apply to a UAV, or where such provisions would conflict with other recommendations contained herein, flight should be conducted in accordance with the general operating and flight rules of part 91, the AIM, and other FAA guidance.

b. The procedures and criteria recommended in this AC apply to UAVs that can be both monitored and controlled in real-time by a human operator in an AVCS. Those UAVs that do not have this capability should not operate outside of special use airspace. However, nothing herein is meant to preclude the operation of a UAV in autonomous or programmed flight mode, provided that a UAV crewmember is continuously monitoring UAV performance, and UAV crew are capable of immediately taking active control of the UAV.

8. ALCOHOL OR DRUGS. Specific medical recommendations are contained in AC XX-XX, UAV Operator Qualification and Training. Additionally, UAV flight crewmembers should refrain from any use of alcohol, drugs, medications, or other substances having effects adverse to the safe completion of UAV operations. Under no circumstances should a crewmember consume alcohol less than 8 hours prior to his or her operation of a UAV.

9. AVAILABILITY OF UAV FLIGHT MANUAL. UAV flights should not be conducted unless current UAV flight manuals are immediately available to all the UAV flight crewmembers.

10. EQUIPMENT AND INSTRUMENTATION. Outside of restricted areas or warning areas, equipment should be installed on the UAV or be available to the internal pilot and/or pilot in command, as discussed below.

a. Lighting.

(1) Anticollision Lights. For all UAV operations in the NAS, anticollision lights should be installed in accordance with the criteria of 14 CFR § 23.1401. The UAV internal pilot should have the capability to turn these lights on and off while the UAV is airborne. However, they will normally be turned on at all times during which the UAV is in flight, unless otherwise directed by the authority controlling the airspace involved.

(2) Position Lights. For operations between sunset and sunrise, UAVs should have position lights installed in accordance with the provisions of §§ 23.1385 through 23.1397. The UAV internal pilot should have the capability to turn these lights on and off while the UAV is airborne; however, they may be turned on at all times during which the UAV is in motion, unless otherwise directed by the authority controlling the airspace involved.

b. Instrumentation. Instrumentation should be provided as recommended below. (Note: This information will not necessarily be available in the event that the UAV telemetry link fails.)

(1) Standard Instrumentation. The UAV system should provide the external pilot, if any, with all of the instrumentation specified by § 91.205 for Visual Flight Rules (VFR) flight. In addition, the internal pilot and the pilot in command during Instrument Flight Rules (IFR) operations, should be provided with all of the instrumentation specified by § 91.205 for IFR flight.

(2) Radar Altimeter or Equivalent. For UAVs that do not perform both their launch and recovery using an external pilot, a radar altimeter should be installed in the UAV, unless ATC radar service is available throughout launch and recovery.

b. Autonomous Operation. A preprogrammed, automated flight profile that does not require human intervention for normal operation.

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(2) Radar Altimeter or Equivalent. For UAVs that do not perform both their launch and recovery using an external pilot, a radar altimeter should be installed in the UAV, unless ATC radar service is available throughout launch and recovery.

(3) Additional Sensors and/or Analysis Tools. It may be helpful to provide the operator/pilot with additional sensors and/or analysis tools to detect developing problems that are not obvious from normal instrumentation.

c. Communications systems.

(1) The internal pilot and the pilot in command, other than the external pilot, should be provided with the full communications capability specified for IFR operations by § 91.205.

(2) The external pilot, if any, should be provided with the two-way communications capability specified by part 91 for the airspace in which launch and/or recovery operations are to take place.

(3) The communications architecture should interface with existing ATC equipment and procedures, so that the fact that the pilots are on the ground is not apparent to ATC personnel. When the AVCS is beyond line-of-sight from the ATC facility, this may require either an airborne voice relay on the UAV, or the use of satellite communications.

d. Transponder. UAVs should be equipped with at least an operable Mode C transponder installed in accordance with the provisions of § 91.215. The UAV internal pilot should have the capability to turn the transponder on and off, manually select codes, and squawk ident as directed by ATC, while the UAV is on the surface or airborne. Additionally, the transponder should automatically transmit code 7600 in the event that the control link with the AVCS is lost.

e. Navigation Systems. The UAV system should have navigational systems capable of operating in the NAS with the accuracy required for manned aircraft by part 91 for IFR flight. The UAV pilot in command should be provided with the UAV's exact position, azimuth, and distance, in relation to navigational aids or airports.

f. Real-Time Control Link. A civil UAV operating in the NAS, outside of restricted or warning areas, should be equipped with a control link that provides real-time monitoring and control capability by a UAV operator throughout the operation. Autonomous control or programmed flight of UAVs may be used, provided that the UAV's flight management system allows the UAV pilot to continuously monitor the UAV's flight course and altitude, and also allows the immediate transfer from autonomous control to real-time pilot control of the UAV.

g. Flight Management System (FMS). The UAV should be equipped with an FMS which, in the event of the loss of the real-time control link, operates the UAV systems autonomously in accordance with preprogrammed flight action data, i.e., route,

altitudes, delays, and activation of the flight termination system (FTS). Provisions should be made in this loss-of-link program for automatic activation of the FTS if control is not reestablished within 10 minutes of the UAV's arrival at a designated loss-of-link holding position, unless the loss-of-link program includes provisions for automatic landing.

h. Flight Termination System. UAVs should not operate in the NAS without an operable FTS installed. The FTS should terminate flight without undue hazard to persons or property, and should be independent of the UAV's propulsion system and flight control system. Outside of restricted and warning areas a nonexplosive system should be used, such as one that deploys a parachute. The FTS should be capable of being activated by the UAV pilot and the FMS.

i. Additional Real-Time Remote Intervention Capability. At all times, a UAV in flight should be subject to real-time intervention sufficient to redirect or destroy the UAV in the event of catastrophic failure of any on-board guidance system or flight management system hardware or software. This capability should be separate from and in addition to any FTS that may be installed on the UAV.

j. Weather Avoidance Equipment. UAVs operating beyond the local area or in IFR conditions should have a means of determining the likely presence of severe weather. This could be satisfied by a Storm Scope, on board weather radar, or similar devices, or by real-time access to ground-based weather radar information at the remote control site.

k. Flight Data and Voice Recorders. The UAV system should include a flight data recorder to record UAV systems and navigational status, and a voice recorder to record radio and intercom voice communications. These recorders should meet the intent of § 91.609 and should normally be installed within the AVCS.

11. UAV EXTERIOR COLORS. The exterior of UAVs should be painted with highly visible colors, except as directed otherwise by the authority controlling the airspace involved.

12. NOTIFICATION OF INTENT TO CONDUCT UAV OPERATIONS IN THE NAS.

a. At least 90 days prior to the proposed commencement of UAV operations in the NAS, a notification of intent to conduct UAV operations in the NAS should be made to the Air Traffic Division of the appropriate FAA Region.

b. This notification should provide all the information requested on FAA Form XXXX, Notification of Intent to Conduct UAV Operations in the NAS. A sample form is contained in Appendix 1.

c. Information requested on the form includes:

(1) Name of organization.

(2) Name of responsible person.

(3) Mailing address.

(4) Telephone numbers, including:

(i) Voice number.

(ii) Fax number, if available.

(5) Vehicle data, including both technical specifications and performance data.

(6) Emergency procedures, including the designated "safe areas" that might be used in the event of the loss of the control link, and a description of the FTS.

(7) Beginning date and time.

(8) Ending date and time.

(9) Description of the method to be used in order to provide see-and-avoid capability while the UAV is operating outside of Class A airspace, Class B airspace, and Class E airspace above FL 600, e.g., chase aircraft, primary/secondary radar, etc.

(10) Information regarding whether the UAV operation has been accomplished in a different FAA region.

(11) Any additional remarks.

(12) Certification that the foregoing statements are true.

13. LETTER OF AGREEMENT (LOA).

a. Before conducting civil UAV operations in the NAS, the operator of a UAV should obtain an LOA for Civil Unmanned Air Vehicle Operation in the National Airspace System. This LOA should be received from the affected FAA Region's Air Traffic Division, in response to the notification of intent to conduct UAV operations in the NAS.

b. All requests for deviation from an LOA should be initiated with the FAA Region's Air Traffic Division at least 60 days in advance of the intended operation.

14. COLLISION AVOIDANCE IN LIEU OF CONVENTIONAL SEE-AND-AVOID.

a. Civil UAV flights should be accomplished in as much of a positive controlled environment as is possible to accomplish the mission.

b. Therefore, except when necessary to accomplish the mission or as necessary for departure and arrival, flight operations should be contained within Class A or Class B airspace, Class E airspace above FL600, restricted areas, or warning areas.

c. UAV operations that are to be conducted in Class C and D airspace, Class E airspace below Class A airspace, or Class G airspace, for other than VFR launch and/or recovery using an external pilot, should have some means of collision avoidance, in lieu of conventional see-and-avoid capability, designed to provide an equivalent level of safety. Depending on the particular circumstances of the proposed operation, such a means could include one or a combination of the following methods:

(1) A chase plane.

(2) Ground observers.

(3) Ground-based primary or secondary radar.

(4) An onboard traffic alert and collision avoidance system (TCAS).

(5) Other sensor systems.

15. RIGHT OF WAY.

a. UAVs in a radar environment will normally be maneuvered by the UAV pilot, as directed by ATC, to maintain proper traffic separation.

b. When operating in Class C, D, E (below Class A), or G airspace, UAVs should give way to manned aircraft.

c. If a chase plane is used, then the flight is considered a formation flight of two, and would have the same right-of-way status as aircraft engaged in airborne refueling or towing as defined in § 91.113(d).

16. FLIGHT RULES. Except for those UAV operations contained only in restricted or warning areas, and launch and recovery operations using an external pilot under VFR, UAVs should operate under IFR.

17. NOTICE TO AIRMEN (NOTAM). For each area or route segment of the UAV operation that is not conducted solely within Class A or Class B airspace, restricted areas, or warning areas, a NOTAM should be filed with the appropriate Flight Service Station a minimum of 2 hours, but not more than 72 hours prior to the commencement of UAV flight operations in that area or route segment. These NOTAMs should be periodically updated thereafter as appropriate. These NOTAMs may be broadcast throughout the duration of the UAV operations, stating: "UNMANNED AIR VEHICLE OPERATIONS WILL BE (ARE) IN PROGRESS FROM (time)Z TO (time)Z IN THE VICINITY OF (FRD or route segment described by several FRDs) FROM (surface or altitude) TO (altitude). USE CAUTION WHILE FLYING IN THIS AREA, CONTACT (UAV controlling ATC center) FOR ADVISORIES." Each of these NOTAMs should include the following information:

a. Planned time at which UAV operations commence in that area or route segment.

b. Planned time at which UAV operations cease in that area or route segment.

c. Description of that area or route segment. For a single area, this should be described in terms of an FRD. For a route segment, multiple FRDs should be listed.

d. Description of the lower and upper altitude limits of the area or route segment.

18. FLIGHT PLAN. An IFR flight plan should be filed for all UAV operations conducted within the NAS, other than those UAV operations contained only in restricted or warning areas, or when the flight plan requirement is waived by the affected ATC facility.

a. In addition to other items listed herein, the flight plan should include all of the information listed in § 91.169, IFR flight plan: Information required.

b. Due to the nature of typical UAV operations, it is anticipated that planned en route holding operations may be required.

(1) Planned en route holding operations should be filed in the flight plan route section by inserting the holding point, in terms of an FRD, followed by the symbol "/", the letter "D", the number of hours, the symbol "+", and the number of minutes, e.g., ABQ345050/D2+30.

(2) Information concerning the nature of the holding operations (e.g., the type of orbits, the airspace required, etc.) should be contained in the mission briefing to ATC, discussed in paragraph 19 below.

c. Additional information that should be filed with ATC in the remarks section of the flight plan includes:

(1) The reference number of the UAV letter of agreement for UAV operations in the NAS, in the form "UAV LOA NO. XXXX." (A copy of the letter of agreement may be kept on file at the affected FAA center, containing information specific to that model of UAV and type of operation.)

(2) For a UAV launched under the control of an external pilot under VFR, the navigational fix at which the IFR portion of the flight begins, in the form "PICK UP IFR AT [fix/radial/distance]." However, this information is not necessary if the departure in VFR conditions is being conducted under an IFR clearance already received on the ground.

(3) For a UAV recovered VFR by an external pilot, the navigational fix at which the IFR portion of the flight terminates, the navigation fix at which the IFR portion of the flight ends, in the form "RECOVER VFR AT [FRD]." However, this information is not necessary for a recovery in VFR conditions in which IFR will not be canceled until landing.

(4) Chase plane information, if any. If a chase plane is used, then the remarks should state "FLIGHT OF TWO WITH [chase plane type designator] CHASE PLANE."

19. MISSION BRIEFING. At least 1 hour prior to the launch of a UAV, the first crewmember who will act as pilot in command while the UAV is under the control of an internal pilot should verbally brief the affected ATC facility. This briefing may be conducted by telephone. The purpose of the briefing is to inform ATC of those aspects of the mission not provided on either the LOA or the flight plan. Given the nature of UAV operations, the route and remarks section of the flight plan are insufficient to incorporate all of the details needed pertaining to a particular mission. Therefore, at a minimum, the mission briefing should satisfy ATC representatives concerning the nature of:

a. Any VFR launch and/or recovery operations to be conducted by means of an external pilot.

b. Any holding patterns or other operations requested en route in the flight plan.

c. The preplanned flight profile(s) to a designated "safe area(s)," to be conducted in the event of a loss of the control link.

d. The procedures to be followed in the designated "safe area," which could consist either of:

(1) Automated recovery, or

(2) Activation of the FTS.

e. Any other special remarks pertaining to that particular mission that are not included in either the LOA or the flight plan, and that might affect either ATC or other air traffic.

20. WEATHER MINIMUMS. UAV operations should not be conducted in weather that does not meet the minimums specified below. However, under no circumstances should UAV operations be conducted in weather for which the specific UAV system has not been determined capable by the manufacturer or the operator, whichever is more stringent.

a. Wind. UAVs should not be flown when, during the scheduled flight period, wind conditions are outside of, or forecast to be outside of, the operating envelope established for that specific UAV.

b. Visibility and Ceiling.

(1) General. If an external pilot is required for the control of the UAV during launch, then the UAV VFR weather minimums specified in paragraph (2) should exist at the time of launch. If an external pilot is required for the control of the UAV during recovery, then:

(i) For a UAV flight less than or equal to 6 hours in duration, the UAV VFR weather minimums specified in paragraph (2) of this section should be forecast to exist throughout the period beginning 2 hours before and ending 2 hours after the planned time of landing.

(ii) For a UAV flight more than 6 hours but less than or equal to 24 hours in duration, general VFR conditions should be forecast to exist at the planned time of landing.

(iii) For a UAV flight of more than 24 hours in duration, forecast weather minimums for the planned time of landing need not be determined.

(2) VFR. In order to account for the possible increased delay in the taking of evasive action on the part of a UAV compared to a manned aircraft, VFR visibility and clearance from cloud criteria have been increased compared to that of manned aircraft. Except when operating in Class A or Class B airspace, or in a restricted area or warning area, no civil UAV should operate under VFR when the flight visibility is less than 5 statute miles and/or the UAV cannot remain at least 2,000 feet vertically above or below, and 1 mile horizontally from clouds. A chase plane should not be used in conjunction with UAV flight

operations when the VFR criteria described in this paragraph cannot be maintained.

(3) IFR. IFR weather minimums should be as defined in §§ 91.169 and 91.175. However, if the UAV system contains an internal automatic precision landing system capable of the accuracy required for Category 2 or Category 3 landings, such as the Global Positioning System (GPS) (where GPS approaches are approved), or a Common Automatic Recovery System (CARS), then weather minimums should be as defined by the capabilities of the recovery system.

21. PREFLIGHT ACTIONS.

a. Airworthiness. No person should operate a UAV unless it is determined to be in an airworthy condition. The crew chief should be responsible for making this determination. Before flight, the external pilot, if any, and the UAV pilot in command for the first phase of flight to be conducted under the control of an internal pilot, should obtain concurrence from the crew chief that the UAV is in an airworthy condition.

b. Flight Information. Before flight, the external pilot for the launch, if any, and the UAV pilot in command of the first phase of flight to be conducted under the control of an internal pilot, should collectively become familiar with all of the information specified in § 91.103, Preflight Action, except that any known takeoff and landing distance data should be used if no approved manual is available.

22. FUEL REQUIREMENTS. A UAV flight should not be conducted in the NAS unless there is sufficient fuel for the UAV to complete its entire planned mission, then fly to any alternate required, then fly to the designated safe area in the event of a loss of link while near the alternate, then fly in a holding pattern for:

a. At least 45 minutes, for UAV flights of up to 6 hours.

b. At least 90 minutes, for UAV flights of more than 6 hours but less than or equal to 12 hours.

c. At least 180 minutes, for UAV flights of more than 12 hours but less than or equal to 24 hours.

d. At least 360 minutes, for UAV flights of more than 24 hours.

23. LAUNCH USING AN EXTERNAL PILOT. An external pilot should have control over the UAV, and the following procedures should be followed, for those launch operations that are not fully automatic:

a. Positive two-way communications should be established between the UAV internal pilot and external pilot, if the two are not colocated, prior to commencing flight operations.

b. The airspace beginning at the takeoff site and continuing through the airspace to be used for the handoff of control to the internal pilot, including the holding pattern to be used in the handoff, if any, should be within and should be expected to remain within visual range of the external pilot throughout the launch phase of the operation.

c. The UAV should be launched in such a manner to create minimal disruption to other airport traffic, if any.

d. Except at a tower-controlled airport, the first UAV crewmember who will act as pilot in command after control has been handed off from the external pilot should notify the affected ATC facility of the takeoff time immediately after the UAV becomes airborne.

e. The UAV should be visually flown to the designated handoff point, and if necessary, enter a designated pattern for holding, until control is transferred to the internal pilot.

f. If UAV control cannot be safely passed to the internal pilot without loss of visual contact by the external pilot, the flight should be aborted and the UAV recovered by the external pilot.

g. The internal pilot should contact the affected ATC facility and obtain clearance if it has not already been received.

h. The external pilot should maintain positive visual contact with the UAV, and advise the pilot in command of any traffic hazards, until the flight transitions fully to IFR procedures.

i. Upon control transfer from the external pilot, the internal pilot will maneuver the UAV as filed and/or directed by ATC under IFR procedures.

24. IFR PROCEDURES.

a. Launch under IFR. A launch conducted under IFR should be performed in accordance with the IFR departure procedures in the AIM, unless indicated otherwise in this AC.

b. Surveillance. UAVs operating under IFR within the NAS should be continuously monitored for adherence to the approved flight plan by the pilot in command. The pilot in command should make all position and other required reports to the appropriate ATC facility in accordance with § 91.183.

c. Flight Deviations.

(1) When deviations from the flight plan are desired for reasons other than an inflight emergency, the UAV pilot in command should request a modification to the flight plan from ATC. In the event of a flight critical system malfunction or other emergency, the pilot in command should set the transponder to code 7600, and contact ATC to provide information on the failure and to coordinate the UAV flight either to a normal recovery or to activation of the FTS. Any UAV deviations from approved flight plans should be reported in accordance with § 91.187.

(2) Except in an emergency, ATC may decline requests for flight deviations below Class A airspace or outside of Class B airspace, if the deviation would place the UAV outside of the airspace defined for the UAV operation in the NOTAMs.

d. IFR Recovery. A recovery conducted under IFR should be performed in accordance with the IFR approach procedures contained in part 91 and the AIM, unless otherwise indicated in this AC.

25. RECOVERY USING AN EXTERNAL PILOT. An external pilot should have control over the UAV and the following procedures should be followed for those recovery operations that are not fully automatic:

a. The airspace beginning at the point at which control is handed off to the external pilot, and including the holding pattern used for the handoff, if any, and ending at the landing site, should be within visual range of the external pilot throughout the recovery operation.

b. Positive two-way communications should be established between the UAV internal pilot and external pilot, if the two are not colocated, prior to transferring control back to the external pilot for recovery.

c. Normally, the UAV will be flown in a radar environment to a predesignated recovery point, enter a holding pattern, and hold until visual contact of the UAV is acquired and control is transferred to the external pilot.

d. In the event that a normal recovery cannot be accomplished due to equipment failure, inability of the external pilot to gain or maintain sufficient visual contact with the UAV, or weather outside of approved limits, the UAV should be flown to a predesignated safe area where the FTS may be activated.

e. Except at a tower-controlled airport, the pilot in command should notify the affected ATC facility of the landing time, immediately after landing.

26. PILOT RESPONSIBILITIES DURING LAUNCH AND/OR RECOVERY OPERATIONS THAT USE AN EXTERNAL PILOT.

a. External Pilot Responsibilities. While exercising control over the UAV, the external pilot should be responsible for maintaining safe traffic separation, collision avoidance, and compliance with airspace restrictions.

b. Internal Pilot Responsibilities. While the external pilot operates the UAV, although the external pilot should be pilot in command, the internal pilot should monitor the launch or recovery evolution to verify the UAV flight path, performance, and compliance with airspace restrictions and ATC clearances. Where necessary, the internal pilot should alert the external pilot and provide whatever guidance is needed to correct deviations.

27. COMMUNICATIONS. In addition to those communications procedures recommended elsewhere in this AC for certain phases of operation, the following are general communications procedures recommended for UAV operations:

a. The UAV pilot in command should initiate and maintain all of the two-way radio communications required by part 91 for the flight rules under which, and the airspace within which the UAV is operating.

b. For the duration of the operation, the UAV pilot in command should maintain two-way radio communications with any other pilot who is operating the UAV, as well as any ground observer who, or chase plane that, is considered necessary for the safe conduct of the operation.

c. Upon initial check-in with an ATC facility, the pilot in command should request a direct telephone number for the ATC controller for use should radio communications fail.

d. In the event of failure of two-way radio communications between the UAV crewmembers and ATC, the UAV transponder should be set to code 7600, and attempts should be made to establish contact via telephone. Pending the reestablishment of communications with ATC, the UAV should be controlled in accordance with § 91.185.

28. FLIGHT TESTING AND TRAINING OPERATIONS. To the maximum extent possible, UAV flight testing and training operations should be conducted within special use airspace, subject to the provisions for such operations stated below.

29. OPERATIONS IN SPECIAL USE AIRSPACE.

a. UAV operations should not be conducted in special use airspace without prior permission from the using or controlling agency, as appropriate.

b. If permission for such operations is granted by the appropriate agency, then UAV operations should comply with any conditions or limitations imposed upon such operations by that agency.

30. OPERATIONS WITHIN MILITARY OPERATIONS AREAS AND MILITARY TRAINING ROUTES. Operations by civil UAVs within military operations areas (MOAs) and military training routes (MTRs) should not be conducted, unless these UAV flights are scheduled and approved by the appropriate military airspace scheduling authority.

31. HAZARDOUS OPERATIONS. No UAV operation should be conducted in a manner that creates a hazard to persons or their property.

32. DROPPING OF OBJECTS. No object should be dropped from a UAV in flight, if such action creates a hazard to persons or their property.

33. AIRSPEED AND OTHER LIMITATIONS. UAVs should observe the airspeed and other limitations, if any, applicable to aircraft, and appropriate to the airspace in which the UAV operations are conducted.

34. OPERATIONS IN THE VICINITY OF PERSONS AND PROPERTY.

a. UAV operations should not be conducted within 1,500 feet of any person or property that is not associated with such operations.

b. UAV operations should be avoided over a congested area of a city, town, or settlement, or open-air assembly of persons not associated with such operations.

35. TOWING OF OBJECTS. No UAV should be operated to tow any banner, streamer, or antenna longer than 20 feet, or any other object that may obstruct the path of another aircraft that may overtake, pass, or fly by the UAV while it is in flight.

36. NOISE ABATEMENT. UAVs should follow applicable local noise abatement procedures as may exist, consistent with the safe operation of the vehicle.

37. PROHIBITED OPERATIONS. Certain UAV flight operations should not be conducted in the NAS. These include:

a. Operating VFR conditions on top, as outlined in § 91.179(a).

b. Special VFR operations.

c. Operating where icing conditions may exist, i.e., visible moisture and a temperature below 0 degrees Celsius, without proper deicing equipment as specified by § 23.1419.

d. Performing aerobatic maneuvers, except in restricted or warning areas.

e. Operating at true flight Mach numbers greater than 1, except in those restricted areas or warning areas where approval for manned aircraft operations at speeds greater than Mach 1 already exist.

38. EMERGENCY PROCEDURES.

a. Responsibility and Authority of the Pilot in Command. In an inflight emergency requiring immediate action, the UAV pilot should comply with the procedures contained in the operations letter of agreement established with the FAA ATC facility.

b. Catastrophic Failure. If a catastrophic failure occurs that may pose a hazard to any person or property other than the UAV itself, the UAV operator should immediately attempt to redirect the UAV to prevent harm from occurring.

c. Loss of UAV Control Link. A UAV that has lost its control link constitutes an emergency. ATC will base control of other air traffic on the procedures contained in the letter of agreement between the ATC facility and the UAV operator.

Thomas C. Accardi
Director, Flight Standards Service

APPENDIX 1

SAMPLE

FAA FORM XXXX

NOTIFICATION OF INTENT

TO CONDUCT CIVIL UNMANNED AIR VEHICLE OPERATIONS

IN THE NATIONAL AIRSPACE SYSTEM

[/ /]

U.S. Department of Transportation FEDERAL AVIATION ADMINISTRATION APPLICATION FOR CERTIFICATE OF AUTHORIZATION FOR UAV OPERATIONS IN THE NAS	FOR AIR TRAFFIC DIVISION USE ONLY Region | Date Action ☐ Approved ☐ Disapproved (Explain in Remarks) Signature of Authorized FAA Representative

INSTRUCTIONS

Submit this notification in triplicate (3) to the appropriate FAA Region, Air Traffic Division. All of the items on the form should be completed.

Supplemental material, including photographs, which may assist the FAA in evaluating the particular UAV operation, may also be submitted.

1. Name of organization	2. Name of responsible person
3. Mailing address Street, route/box number	City State/ZIP code
4. Telephone number	Fax number

5. Attach a supplement, titled "VEHICLE DATA," which states the UAV's name; a listing of the vehicle's dimensions; its operational performance characteristics (i.e., takeoff speed, climb speed, cruise speed, holding speed, approach speed, landing speed, rate of climb, rate of descent, runway requirements, etc.); and the flight operating systems, including the navigation system, transponder, aircraft lighting, flight termination system, control link features (e.g. line of sight, UHF beyond line-of-sight, or satellite communications, and autonomous flight capability).

6. Attach a second supplement, titled "EMERGENCY PROCEDURES," which describes the location of the designated "safe areas" that might be used, and the nature of the flight termination system.

7. Beginning (date and time)	8. Ending (date and time)

9. Define what method will be used to provide see-and-avoid while the UAV is operating below Class A airspace, e.g., chase aircraft, primary/secondary radar, etc.

10. Has this proposed UAV operation been accomplished in a different FAA Region? ☐ No ☐ Yes (If yes, attach copy of the proposal submitted to that Region and the issued LETTER OF AGREEMENT FOR UNMANNED AIR VEHICLE OPERATION IN THE NATIONAL AIRSPACE SYSTEM.)

11. Remarks

12. Certification - I CERTIFY THAT THE FOREGOING STATEMENTS AND ATTACHED SUPPLEMENTS ARE TRUE.

Date Signature of applicant

APPENDIX 2

SAMPLE

LETTER OF AGREEMENT

FOR UNMANNED AIR VEHICLE OPERATIONS

IN THE NATIONAL AIRSPACE SYSTEM

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

LETTER OF AGREEMENT FOR UNMANNED AIR VEHICLE (UAV) OPERATION IN THE NATIONAL AIRSPACE SYSTEM

ISSUED TO

ADDRESS

This letter is issued for the UAV operation described herein. No person should conduct any UAV operation pursuant to the authority of this letter except in accordance with the standard and special provisions contained herein, and such other requirements of the Federal Aviation Regulations not waived by this letter.

OPERATIONS AUTHORIZED

STANDARD PROVISIONS

1. A copy of the application made for this certificate shall be attached and become a part hereof.
2. This letter should be presented for inspection upon request of any authorized representatives of the Administrator of the Federal Aviation Administration, or any State or municipal official charged with the duty of enforcing local laws or regulations.
3. The holder of this letter should be responsible for the strict observance of the terms and provisions contained herein.
4. This letter is nontransferable.

Note: This letter constitutes authorization for operation of a UAV in the national airspace system (NAS). It does not constitute a waiver of any State law or local ordinance.

SPECIAL PROVISIONS

Special Provisions Nos._____ to _____, inclusive, are set forth on the reverse side hereof.

This letter is effective from _____ to _____, inclusive, and is subject to cancellation at any time upon notice by the Administrator or his authorized representative.

BY DIRECTION OF THE ADMINISTRATOR

_____ _____

(Region) (Signature)

_____ _____

(date) (title)